RESTRICTED CIRCULATION

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ENVIRONMENTAL AND OTHER MEASUREMENTS MADE DURING LAMBING WATCH AT GREAT HOUSE EHF DURING THE NIGHT OF 8-9 APRIL 1980

AGRICULTURAL MEMORANDUM NO. 897

1. INTRODUCTION

Meteorological measurements have been made on the lambing field, Stone Law, during the lambing periods of 1978-79-80 in order to relate lamb mortality to weather stress. (Refs 1 and 2)

From the autumn 1979 tupping dates it was calculated that most births should occur on the night of 8-9 April 1980. A lambing watch, to be kept jointly by the Great House staff and by staff of the Meteorological Office at Harrogate was planned for this night. A measuring plan was devised so that if stressing weather did not occur on that night measurements would be made to assess:-

(a) The character of the air flow over Stone Law including drainage of cooled air.

(b) Weather related sheep behaviour.

(c) The heat gain and loss of the walls.

(d) The usefulness of the infra red detector thermometer.

2. OBSERVING PLAN

Thus, while the EHF staff made observations of animal behaviour, staff from the Meteorological Office at Harrogate made observations at the Meteorological enclosure on Stone Law of:-

(a) Dry bulb temperature.

(b) Wet bulb temperature.

(c) Cloud cover.

(d) Grass temperature.

(e) Earth temperatures at depths of 10, 20 and 30 cm.

(f) Run of wind.

(g) Wind speed and direction.

Measurements (a), (b) and (e) were made with mercury in glass thermometers, (d) were made using an alcohol in glass (grass minimum) thermometer and with an infra red detector (Ref 3). Run of wind measurements (f) were made by a standard Met. O cup counter anemometer at a height of 2 m and a record of wind speed and direction was provided by a Woelfle Recorder (Ref 4).

A second Woelfle Recorder provided a record of wind speed and direction at a height of 2 m on the sloping crest of the N-S ridge which bisects Stone Law (see Fig 1). A record of air temperature at a height of 0.5 m was made by a bimetallic thermograph housed in a Stevenson type screen hard up against the NE wall (see Fig 1).

At each observing time the infra red detector was used to measure the skin temperature of each side of the SW and NE walls at the positions A and B shown on Fig 1.

Observation times were: (all times GMT)

17.20, 19.00, 20.30, 22.30, 00.30, 02.10, 04.15, 06.00

At 04.15 GMT, thermally inert smoke was released from a point on the ridge on Stone Law and from the mid-point of the empty adjacent grassed field. (See Fig 1)

At 04.30 GMT the infra red detector was used to plot temperature profiles of resting places recently vacated by two ewes and their lambs.

Measurements are plotted in Figs 2-9.

3. THE WEATHER SITUATION

An anticyclone which had moved from Biscay became established over the British Isles on the 3rd of April. Apart from a temporary retreat to the W of Ireland which allowed moderate NW'ly winds to cover England and Wales for a time on the 8th it dominated the weather throughout the lambing period before moving to the continent on the 11th. During the night of the 8-9th the anticyclone was slow moving to the West of Ireland whilst a weak warm front affected the North of Ireland and Scotland. A ridge of high pressure extended over England and Wales with light NW'ly winds below 3000 ft.

The night proved to be one of classic radiation cooling, the air and grass temperature curves in Fig 2 clearly show the discontinuity described by Saunders (Ref 5). All low cloud cleared before dusk leaving only traces of cirrus. The wind at 2 m which had been 4 m/sec (9 mph) from the NW during the late afternoon became less than 0.8 m/sec (1.8 mph) from 22.00 GMT. A ground frost formed at 20.00 G. Apart from the traces of cirrus the sky remained clear until at 06.00 G on the 9th, when orographic low stratus formed over the high ground (300 m) to the NW of Stone Law and moved across the Great House Valley in the NW'ly air flow, giving $\frac{3}{8}$ cover at times.

By 0700 G the 2 m wind had freshened to 2.5 m/sec (5 mph) from the NW and became 4.0 m/sec (9 mph) by 10.00 G.

4. GENERAL AIR CIRCULATION

The 1800 G upper air ascent from Aughton on the 8 April showed that the 300 m and 1000 m winds were 6-9 m/sec (14-20 mph) from 340°. Winds at these heights backed to 310° by 0600 G on the 9th but the speed was maintained throughout the night. The surface (2 m) wind over Stone Law during the afternoon and evening of the 8th was 4 m/sec (9.0 mph) from the NW.

Beneath the steady upper flow, the air in the Great House valley became very slow moving as the valley slopes cooled, the plane of separation being at the height of the hill crests. Below this height (300 m), there developed a circulation of air quite separate from the upper flow. A ground frost was first recorded at 2000 G and air cooled by contact with the ground began to flow down the slope, air in the

lowest ½ metre or so taking about 8 minutes to travel from the hill crest to the valley bottom where it became very slow moving. One interesting feature of the wind record (Fig 7) is that the upper current of air moving across the valley appeared, particularly between 0100 and 0300 G by which time there had been several hours of downslope motion, to mix down to the valley slope presumably to replenish air 'lost' by drainage. During three distinct 15 minute periods separated by 15 minutes of near calm, the 2 m wind freshened initially from 230-250° but veered quickly to become 310°, the direction of the upper cross valley flow, by the end of each period. (See A, B and C, Fig 7)

5. DOWNSLOPE DRAINAGE OF COOLED AIR

In order to measure the scale of downslope flow of air in direct contact with the cool slopes of the valley, thermally inert smoke was released at 04.15 G at ground level from the mid-point of the field immediately to the NE of Stone Law. (See Fig 1). This grassed field, empty of stock, falls at about the same slope as Stone Law but with a longer downhill dimension (300 m).

At 04.15 G grass temperature was between -3 and -4°C and the wind at 2 m (from the Woelfle trace) was less than 0.5 m/sec. The shape of the resulting smoke plume is shown in Fig 6.

The candle has to be ignited to produce smoke so although the smoke rapidly takes up the temperature of its environment it is, for a short time, slightly warmer than the environment. This was fortuitous because although 90% of the smoke remained within 0.5 m of the grass surface the remainder rose to a height of some 5-10 m and exhibited a slowly rotating uphill motion. Some wisps of smoke from the crest of the rotor were seen to move slightly uphill whereas the body of the rotor moved very slowly downhill before dispersing. The downslope speed of the smoke retained with 0.5 m of the surface was, however, about 0.8 - 1m/sec. This smoke remained close to the surface until a 2 m high wall was reached some 60 m from the release point. Here it lifted over the wall rising to a height of 6-8 m and slowing markedly before dispersing down-wind of the wall.

6. EWE BEHAVIOUR

About one third of the ewes had lambed during the quiet weather conditions of the 3rd to the 8th April and in the event no lambs were born during the night of the 8th-9th.

During the 24 hour watch which commenced at 1600 G on the 8th the Great House staff noted, at each hour, the positions of the ewes and whether they were grazing or resting. The percentage of animals grazing at each hour is shown in Fig 8 and shows a main grazing period between 1300 and 2000 G.

For the remainder of the 24 hours the length of time when the majority (> 50%) of the flock were resting is almost exactly equalled by that when the majority were grazing. Most of the flock rested immediately after the main afternoon and evening grazing period but the longest resting period was between 0130 and 0430 G, by which time drainage (down the slope) of cooled air was well established. This shallow layer of air, which had a temperature by this time of below 0°C was measured to be moving down-hill at about 1 m/sec (2.2 mph).

Alexander's general findings as to heat loss of young lambs, summarised in Fig 10 (Ref 6), show those critical combinations of wind speed, temperature and state of coat, in which a young, light weight lamb is likely to succumb. Such a lamb born during the early hours of the 9 April and with its coat wetted by birth fluids would have been at considerable risk due to the ventilation caused by the half metre deep layer of freezing air draining downhill across Stone Law. It is

thus reasonable to suppose that a ewe with an attendant lamb or about to give birth would choose to rest in the most sheltered parts of the field. Fig 9 shows the hour by hour resting places and it is clear that during the period when downslope motion of cooled air was well established the ewes moved uphill to gain the shelter of the NW and NE boundary walls.

That these apparently 'quiet' weather conditions can give rise to stress was evidenced by the finding, at 2000 G on the 8th, of a lamb which had become separated from its mother in the dusk. With a rectal temperature already several degrees below normal it was clearly succumbing. It was removed from the field and revived with warm feeds. A second lamb, sheltering against a fence post was found to be shivering but was left in the field after being reunited with its mother.

By the early hours of the morning a thick layer of frost was present on the grass. It was then noticed that although the grass was frosty close to the sides and rear of each resting ewe the ground in front of a ewe was thawed over an area of 2-4 sq ft. It was here that lambs tended to sit or lie. One ewe, with an attendant lamb was seen to laboriously edge backwards while still in the resting position as if to provide a newly warmed patch of ground for her lamb.

Several patches of thawed grass were visible over the field where ewes had moved away to graze. Temperature measurements, made with the infra red detector, of one such patch are shown in Fig 5A. Measurements made immediately after a ewe had left her resting place are shown in Fig 5B. Here it was noted that the ewe had urinated, so supplying an extra quantity of heat to the ground.

Many of the thawed patches inspected included high proportions of bare soil which would be warmed more quickly by the resting ewe than the grassed areas. Fig 2 shows that the ground temperature at 10 cm depth under the bare soil patch in the enclosure was for much of the night 6-8°C warmer than the grass surface. It is thus possible that resting places were carefully chosen by the ewe. Inspection of birth sites, several of which included patches of bare soil, showed that the ewes chose to give birth in shallow depressions often only 20-25 cm deep in the otherwise flat field surface, presumably to gain protection from the wind.

7. MEASUREMENT OF WALL SKIN TEMPERATURE

At each observation time the infra red detector was used to measure the temperature of each side of the walls AB and CD at the places shown in Fig 1.

No systematic vertical temperature gradients were evident in the walls so each measurement was made by scanning from the foot to the top of the wall and deriving a mean temperature. Fluctuation in all scans was less than $\pm$ 0.5°C.

Before each pair of measurements (one each side of the wall) were made the instrument was recalibrated to reduce the possibility of zero shift.

The results are shown in Fig 3 together with the air temperature as measured by bimetallic thermograph at a height of 0.5 m and 0.3 m away from the wall AB. (The 20.00 G reading for wall CD is omitted from Fig 3 as the temperature measured (4°C) is suspected as being a simple misreading of the temperature scale.) The curves for each wall are similar in character and both sides of each wall had temperatures several degrees higher than that of the surrounding air.

The temperature of stones in the body of the wall was found to be 4-6°C, similar to that of the nearby earth at a depth of 30 cm, (see Fig 2).

Measurements made on a previous sunny but cool day showed the wall skin temperature to be more than 8°C higher than the air temperature (20°C and 11.8°C respectively).

8. COMPARISON OF GRASS TEMPERATURE MEASURED BY ALCOHOL IN GLASS THERMOMETER AND INFRA RED DETECTOR

Fig 4 shows curves of grass temperature measured at the Met. Enclosure by two different methods. Although the curves are similar in character, at all times the temperature as measured by the infra red detector was 1-2°C higher than by the alcohol in glass thermometer. (Subsequent single point checks of each thermometer showed them each to be reading within 0.2°C of measurements made with an Inspector's thermometer.)

Explanations for the difference shown in Fig 4 include:-

(a) The possibility that small areas of bare soil were included in the field of view of the IR detector because it was pointed vertically downwards at the grass.

(b) The formation of dew and then frost on the bulb of the alcohol in glass thermometer caused it to under-read due to evaporation.

(c) The emissivity of the grass surface altered when dew and frost formed on the leaves.

9. NOTES FOR FURTHER STUDIES

(a) Weather Stress. In long term studies of weather stress it is usually appropriate to derive conditions at lamb height from measurements which have perforce to be made at heights of one or two metres. Where such studies are conducted in hilly terrain, particularly at times of strong night time radiation it is only by measuring wind speed and temperature below a height of half a metre can the full extent of stress due to the downslope drainage of cooled air be deduced.

(b) Artificial Shelter. It would seem prudent, where artificial shelter is provided in hilly terrain to orientate at least some of the bales or hurdles typically used, parallel to the contours so as to provide shelter from downslope drainage of cooled air.

(c) Ground Warming. The ewe appears to systematically warm the ground in order to provide an equable resting place for her offspring. One possible by-product of the ground warming and wetting (by warm urine) of resting and birth sites might be that soil borne insects, larvae or nematodes are encouraged to migrate temporarily to the surface and so attract to the field predators such as crows. During the overnight watch, herein described, the animals preferred to rest in the most Northerly part of the field where, being in the lee of the North boundary wall, they were protected from the draught due to the downslope motion of air cooled by contact with the ground. Unseasonal activity of nematodes and insects, precipitated by the resting ewes, would thus tend, in the long term, to be concentrated in such sheltered parts of the field.

(d) Dry Stone Walls. The interior stones of the walls change their temperature only slowly, possibly in step with the deep (30 cm) earth temperature. At the same time the exterior skin of the outer stones experience, in sunny conditions, a greater diurnal variation than that of the surrounding air. The resulting stress created by temperature gradients within individual stones and between adjacent stones will all contribute to the slow deterioration of the walls.

(e) Infra Red Detector Thermometer. This proved to be a most useful device. Profiles of wall temperatures were readily made and without it the scale of ground warming by the ewes would not have been possible.

Care must be taken to ensure that the object or surface to be measured completely fills the field of view of the detector. For example, when measuring grass surface temperature, the possibility of including small areas of bare soil will be much reduced if the detector is pointed at, say, 45° to the surface. Further, changes in emissivity will occur when dew or frost forms on the surface to be measured.

ACKNOWLEDGEMENTS

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Any comments or suggestions about this paper should be referred to the author.

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FIG. 1 THE LAMBING FIELD "STONE LAW"

EQUIPMENT AND MEASURING SITES
8-9TH APRIL 1980

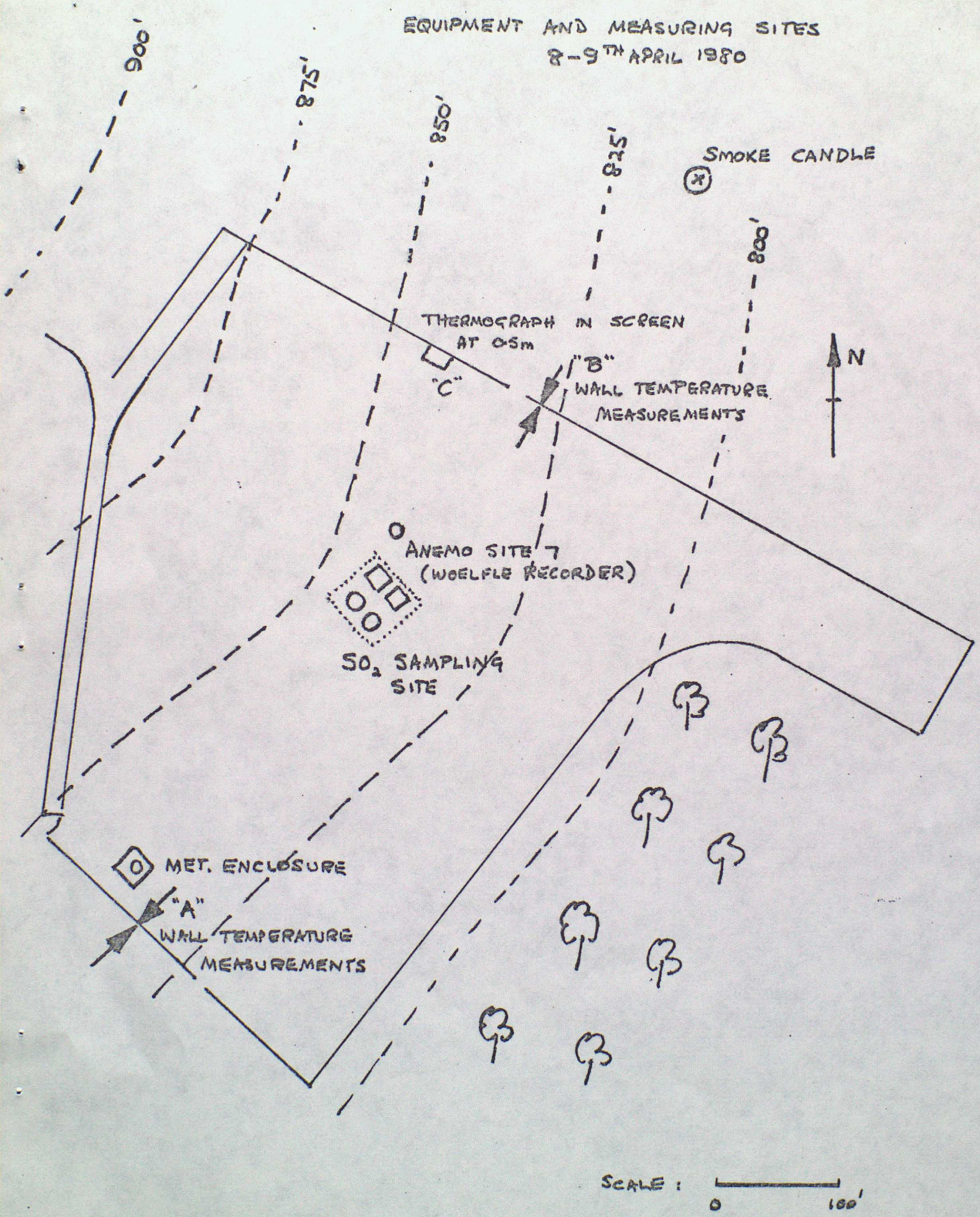


FIG 2 EARTH, AIR AND GRASS TEMPS AT ENCLOSURE

8-9TH APRIL 1980

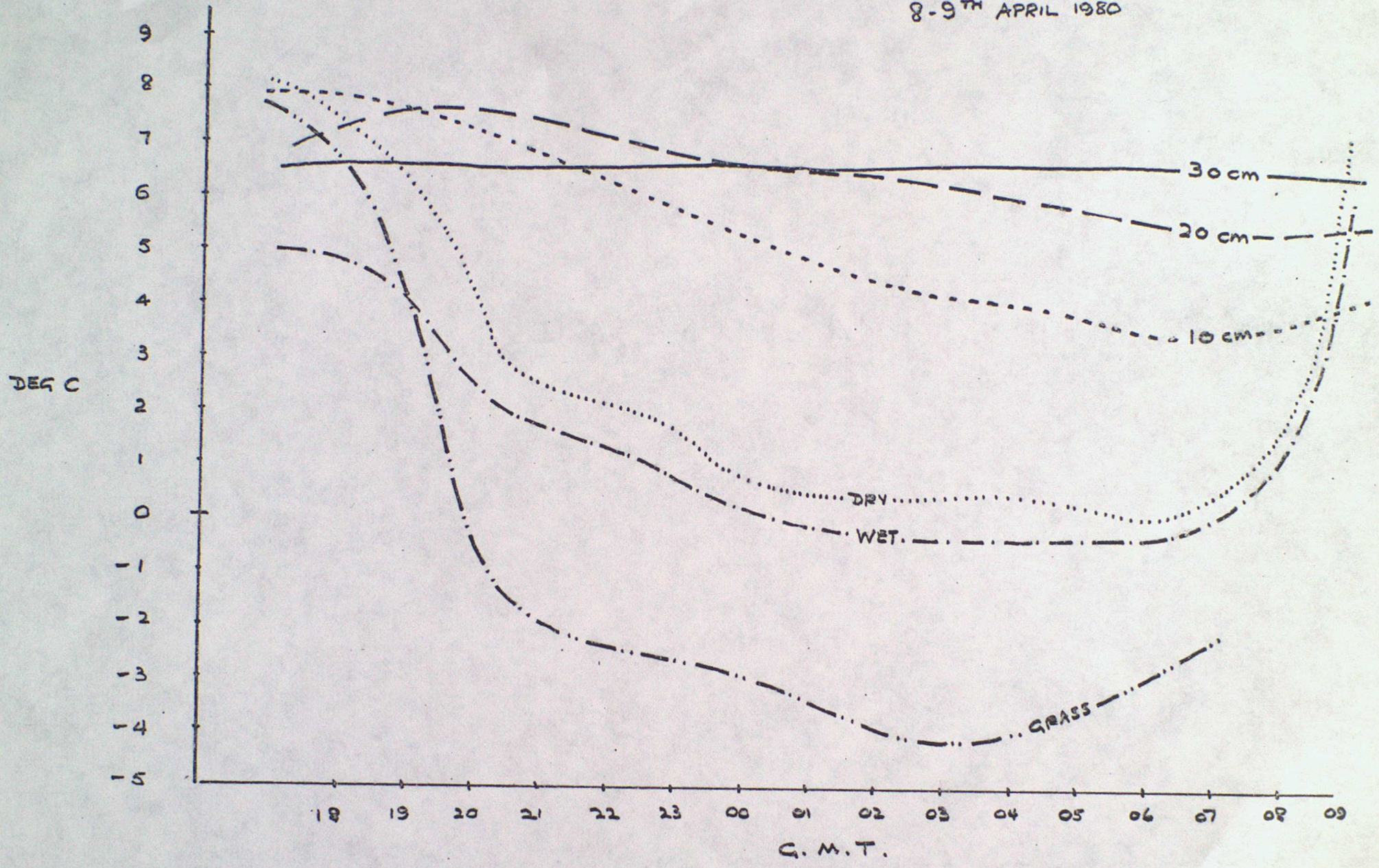


FIG 3 WALL FACE TEMPERATURES (USING IR DETECTOR)

AND AIR TEMPERATURE AT 0·5 m

8 – 9 TH APRIL 1980

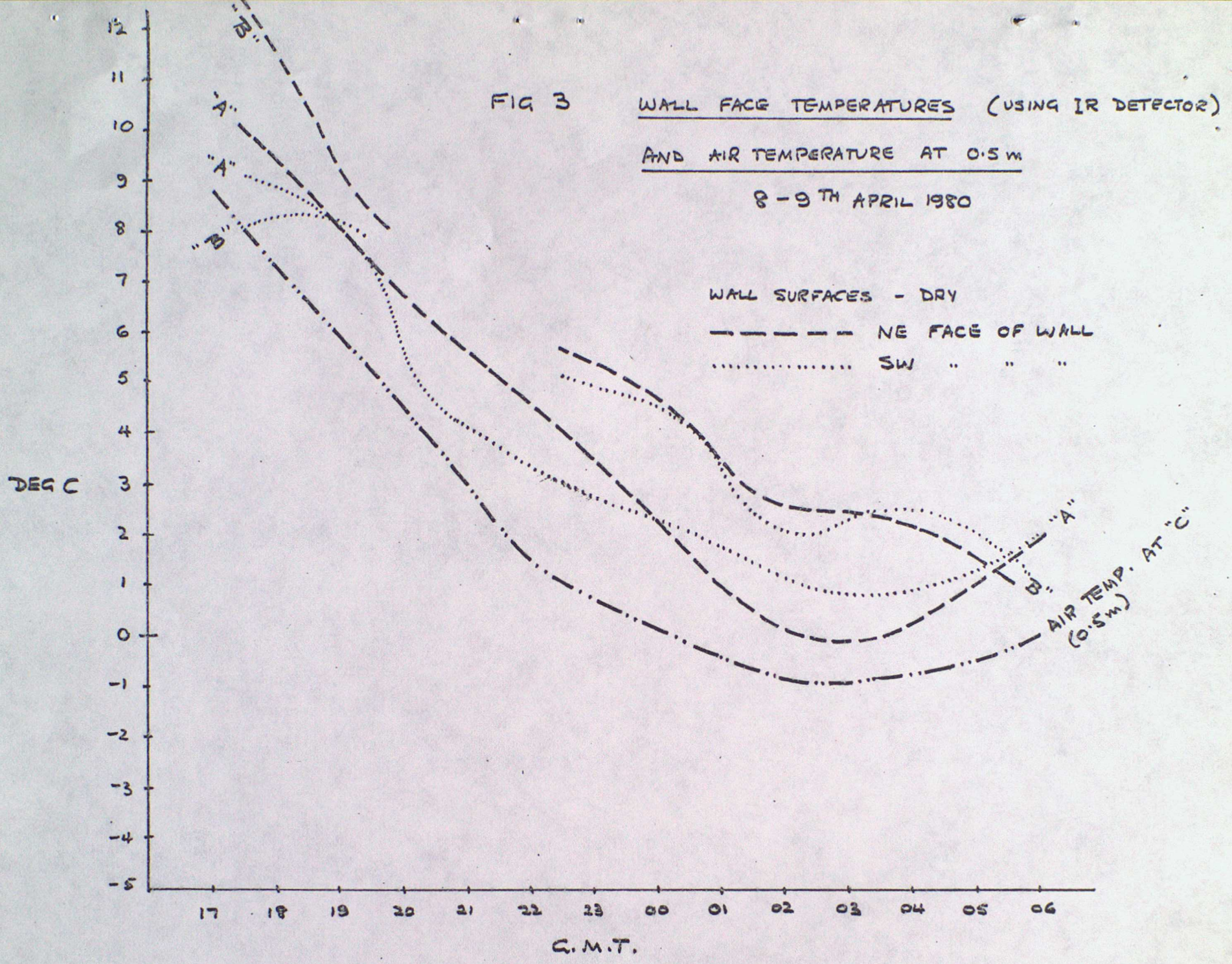


FIG 4 GRASS TEMPERATURE

BY

IR DETECTOR AND ALCOHOL IN GLASS THERMOMETER

8-9TH APRIL 1980

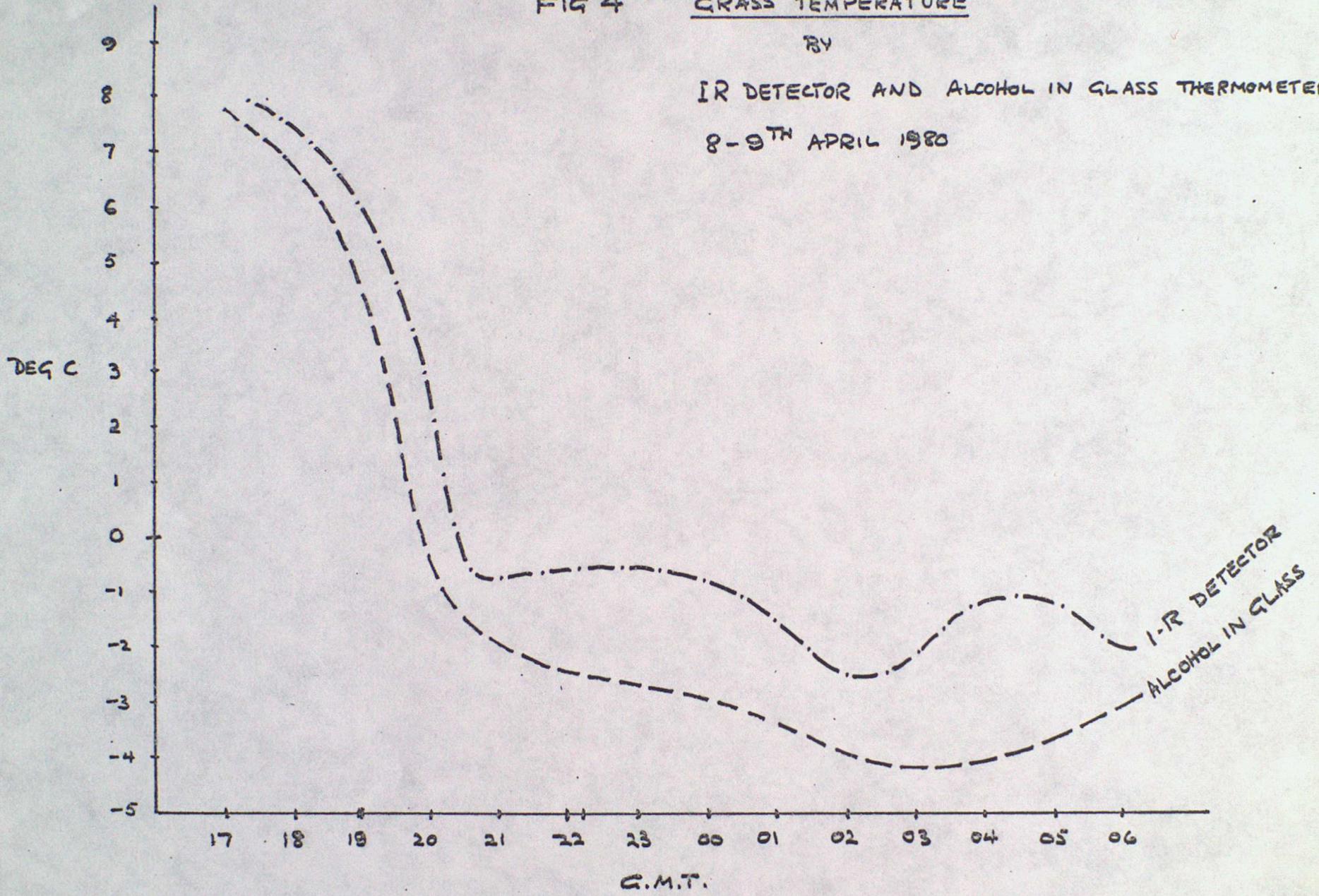


FIG 5

Grass surface temperatures measured with I.R thermometer.

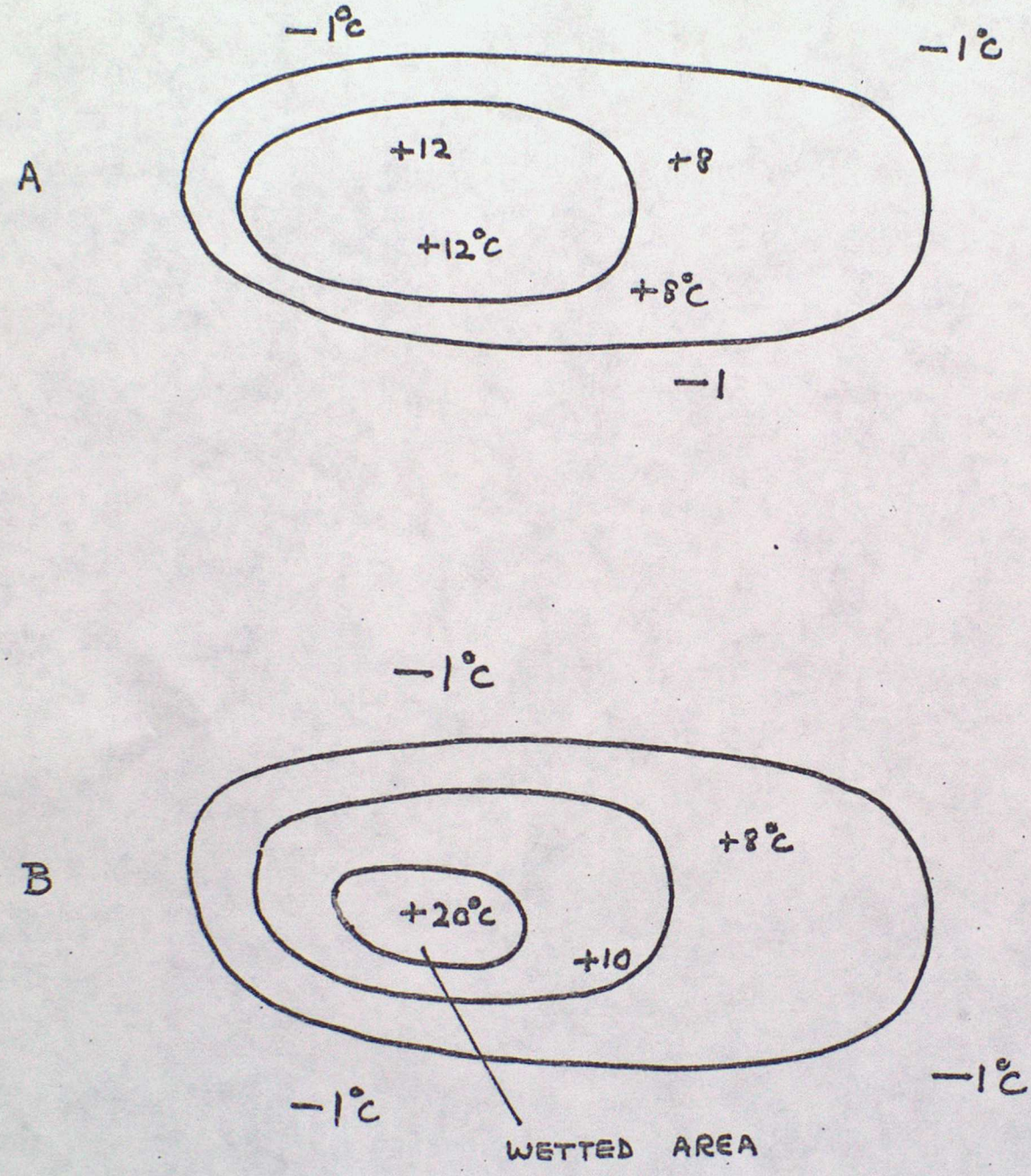
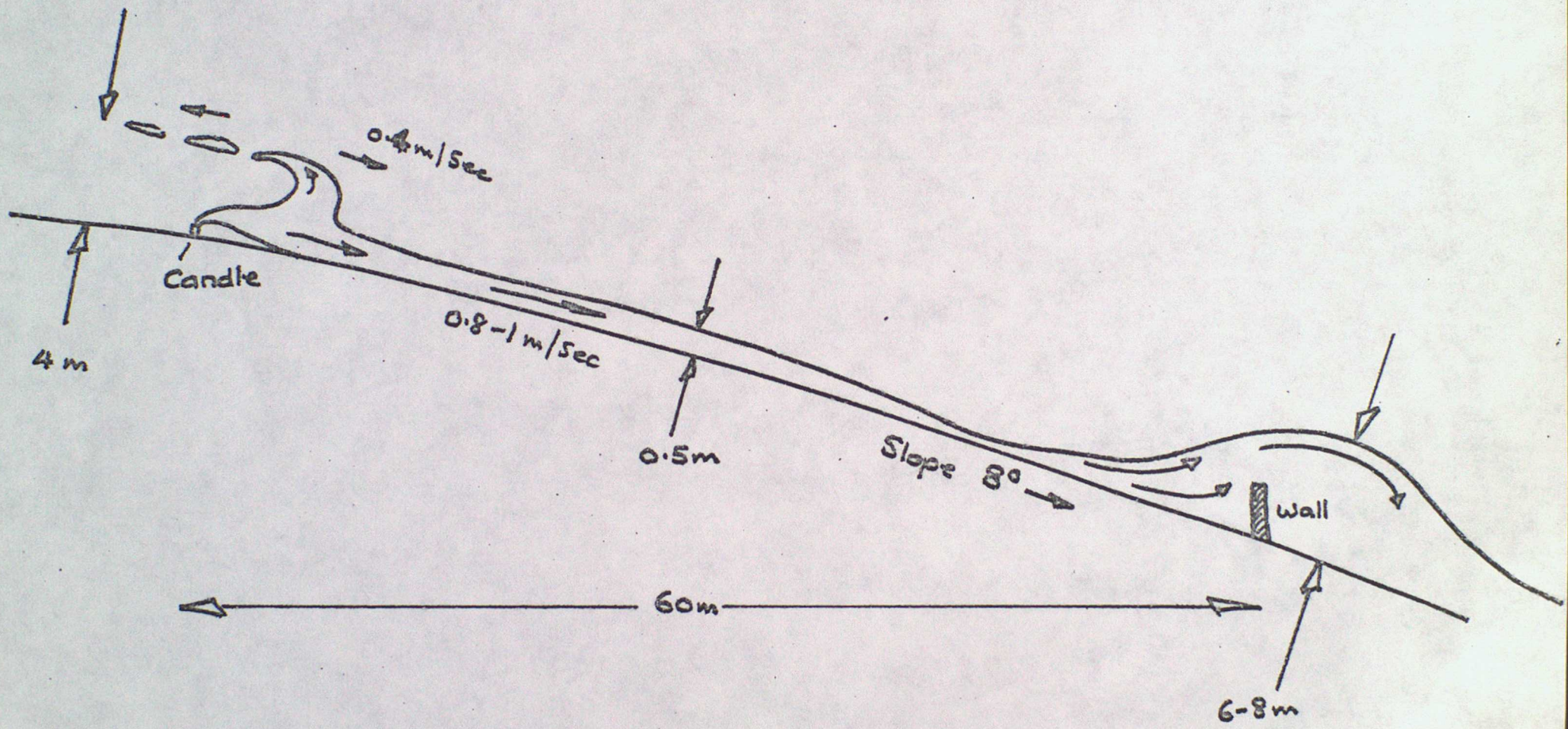


FIG 6

Downslope drainage of thermally inert smoke



WIND SPEED AND DIRECTION RECORDS - "STONE LAW"

FIG. 7.

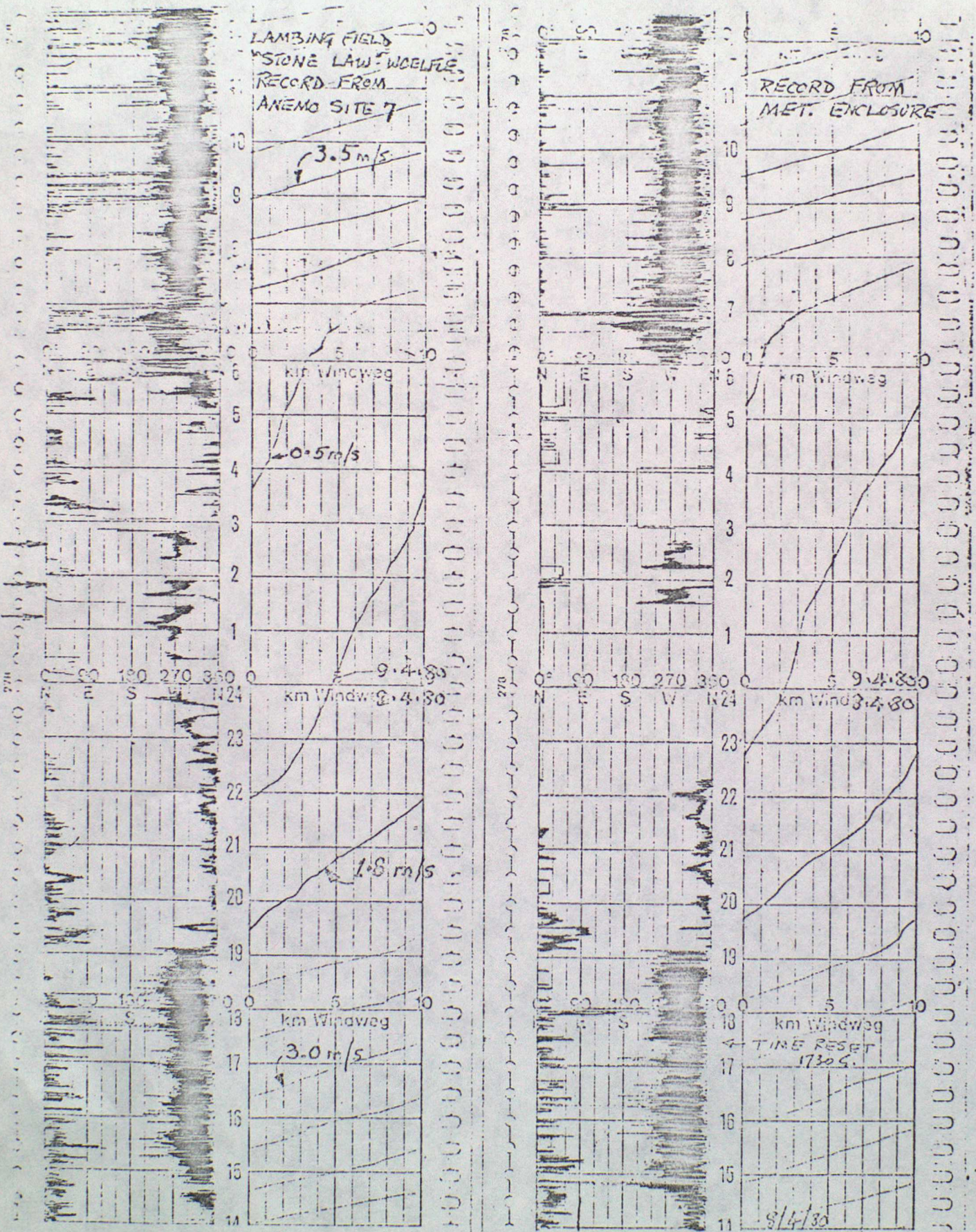


FIG 8 % OF SHEEP GRAZING AT HOURLY INTERVALS

8-9TH APRIL

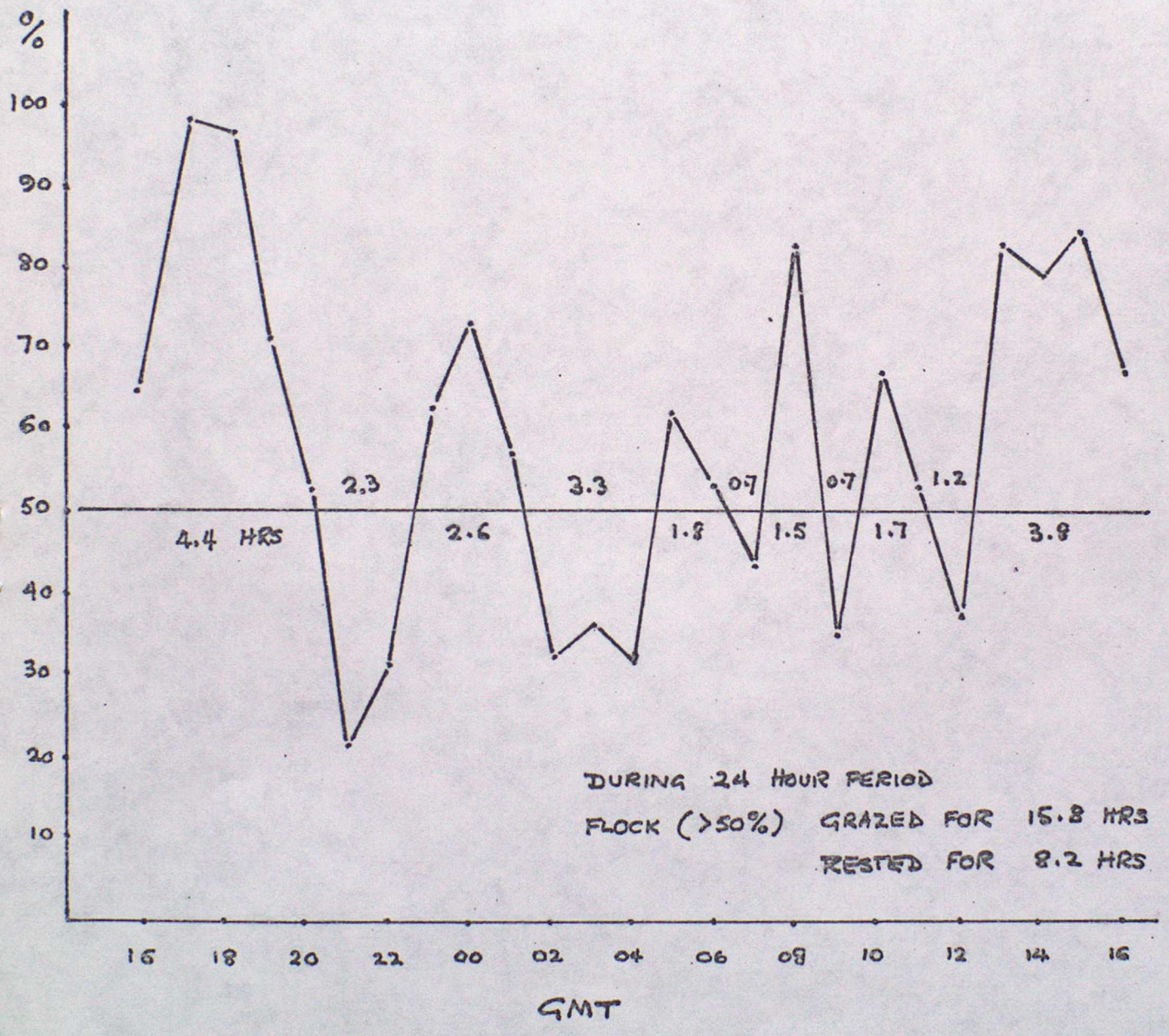


FIG 9

THE LAMBING FIELD "STONE LAW"

RESTING PLACES OF EWES AT HOURLY INTERVALS

N

O = RESTING PLACE

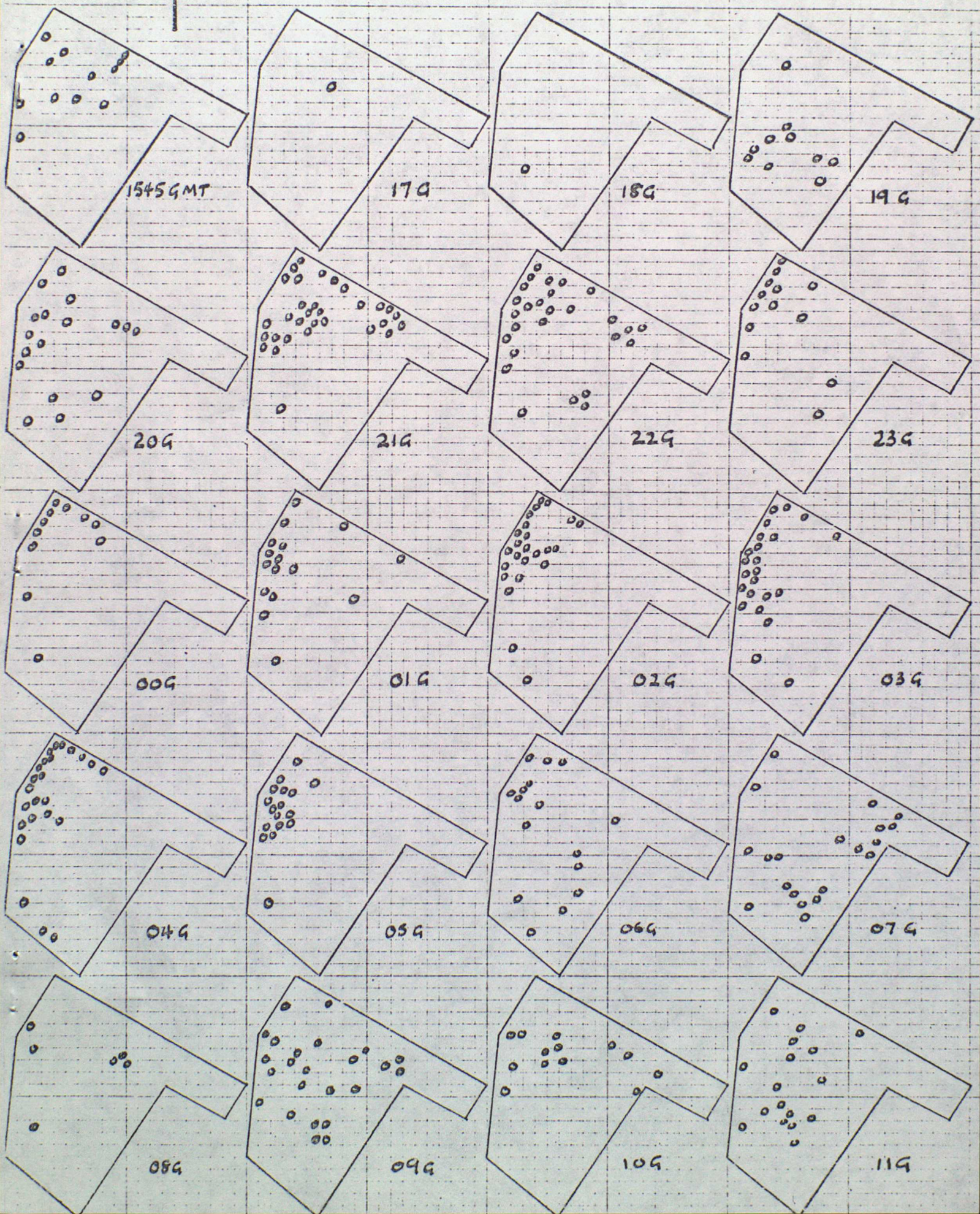


FIG 10 CRITICAL CONDITIONS FOR NEWBORN LAMBS